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Optical Relay Transmission System

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SPECIFICATION

1. Title of the Invention: Optical Relay Transmission System

2. Claims

(1) An optical relay transmission system in which plural optical direct amplifier

repeaters (10A to 10N) for directly amplifying an optical signal are provided in an optical fiber (3) line connecting terminal stations (1, 2) and while said plural optical direct amplifier repeaters (10A to 10N) are gain-controlled by a pilot signal superimposed by amplitude modulation on a main signal as an optical signal which is sent from one terminal station (1) of both said terminal stations (1, 2) and transmitted through said optical fiber (3), an optical signal is transmitted through said optical fiber (3) to the other terminal station (2), characterized in that:

said terminal stations (1, 2) respectively have pilot signal generating means (1a, 2a) to generate plural pilot signals which are as many as said plural optical direct amplifier repeaters (10A to 10N) and different in frequency from each other;

said plural optical direct amplifier repeaters (10A to 10N) have band pass filters (16a to 16n) which have different frequency pass bands each corresponding to either of the frequencies of said plural pilot signals; and

a desired optical direct amplifier repeater (10A to 10N) among said plural optical direct amplifier repeaters (10A to 10N) is gain-controlled by a pilot signal passing through its band pass filter (16a to 16n).

(2) An optical relay transmission system in which plural optical direct amplifier repeaters (30A to 30N) for directly amplifying an optical signal are provided in an optical fiber (3) line connecting terminal stations (1, 2) and while said plural optical direct amplifier repeaters (30A to 30N) are gain-controlled by a pilot signal superimposed by amplitude modulation on a main signal as an optical signal which is sent from one terminal station (1) of both said terminal stations (1, 2) and transmitted through said optical fiber (3), an optical signal is transmitted through said optical fiber (3) to the other terminal station (2), characterized in that:

said terminal stations (1, 2) respectively have pilot signal generating means (1a, 2a) to generate plural pilot signals which are as many as said plural optical direct amplifier repeaters (30A to 30N) and different in frequency from each other, and a single pilot signal which is different in frequency from said plural pilot signals;

said plural optical direct amplifier repeaters (30A to 30N) have band pass filters (16a to 16n) which have different frequency pass bands each corresponding to either of the frequencies of said plural pilot signals and a common band pass filter (31) which has a frequency pass band corresponding to the frequency of a single pilot signal; and

a desired optical direct amplifier repeater (30A) among said plural optical direct amplifier repeaters (30A to 30N) is gain-controlled by a pilot signal passing through its band pass filter (16a) and said plural optical direct amplifier repeaters (30A to 30N) are

gain-controlled on a common basis by a single pilot signal passing through said common band pass filter (31).

(3) The optical relay transmission system as claimed in Claim 2, characterized in that a common optical direct amplifier repeater (40) with said common band pass filter (31) and said optical direct amplifier repeaters (30A to 30N) are arbitrarily combined and provided in said optical fiber (3) line connecting said terminal stations (1, 2).

(4) The optical relay transmission system as claimed in Claim 2, characterized in that said optical direct amplifier repeaters (30A to 30N) having band pass filters (16a to 16n) with the same pass band are provided group by group successively.

(5) The optical relay transmission system as claimed in any of Claims 1 to 4, characterized in that:

said optical direct amplifier repeaters (10A to 10N, 30A to 30N, 40) have a D/A conversion means (21a) which converts a supervisory signal sent from one terminal station (1) of said terminal stations (1, 2) into a DC signal;

the DC signal as a result of conversion by said D/A conversion means (21a) enters a gain control means (19) to gain-control said optical direct amplifier repeaters (10A to 10N, 30A to 30N, 40); and

said gain control means (19) itself is gain-controlled to gain-control said optical direct amplifier repeaters (10A to 10N, 30A to 30N, 40).

(6) The optical relay transmission system as claimed in any of Claims 1 to 4, characterized in that a modulation factor for a pilot signal is displayed on a monitor (50) mounted in said terminal stations (1, 2).

3. Detailed Description of the Invention

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Summary

The present invention concerns an optical relay transmission system which uses optical direct amplifier repeaters for directly amplifying an optical signal. The object of the invention is to provide an optical relay transmission system which uses optical direct amplifier repeaters and gain-controls them individually and sets the gain of each optical direct amplifier repeater to a desired level so as to eliminate wasteful power consumption, reduce the running cost and also prevent a signal deterioration to assure transmission of an adequate signal.

In the optical relay transmission system, plural optical direct amplifier repeaters are provided in an optical fiber line connecting two terminal stations and while the plural optical direct amplifier repeaters are gain-controlled by a pilot signal superimposed by amplitude modulation on a main signal as an optical signal which is sent from one terminal station of both the terminal stations and transmitted through the optical fiber, the optical signal is transmitted through the optical fiber to the other terminal station. It is configured so that the terminal stations have pilot signal generating means to generate plural pilot signals which are as many as the plural optical direct amplifier repeaters and different in frequency from each other; the plural optical direct amplifier repeaters have band pass filters which have different frequency pass bands each corresponding to either of the frequencies of the plural pilot signals; and a desired optical direct amplifier repeater among the plural optical direct amplifier repeaters is gain-controlled by a pilot signal passing through its band pass filter.

Industrial Field of Utilization

The present invention relates to an optical relay transmission system which uses an optical direct amplifier repeater for directly amplifying an optical signal.

Optical relay transmission systems are used, for example, for optical submarine cable communications. Submarine optical relay transmission is superior in transmission quality (noise and delay time) to communication satellites or conventional short wave radio communications and is widely used for international and domestic communications because it is more reliable from the viewpoint of security. Submarine optical relay transmission systems use optical fibers whose transmission capacity is larger than that of conventional coaxial cables. Also, the use of an optical direct amplifier repeater as an amplifying means in an optical relay transmission system has been proposed.

In this type of optical relay transmission system, plural repeaters are provided in an optical fiber transmission line connecting terminal stations at both ends. In many cases, the gain of each repeater individually varies. With this background, an optical relay transmission system in which the gain of only a desired repeater can be controlled has been anticipated.

Prior Art

In a conventional optical relay transmission system, as shown in Fig.13, plural repeaters 4 are located at regular intervals in an optical fiber 3 connecting terminal stations 1 and 2 at both ends; an optical signal is sent from a terminal station 1 to the other terminal station 2 while being amplified by the repeaters 4.

A commonly used repeater type for the above repeaters 4 is as follows: for example, an optical signal transmitted by an optical fiber 3 is converted into an electric signal by a photodiode and the electric signal is amplified by an electronic amplifier and reconverted into an optical signal by a semiconductor laser or the like before being sent back to the optical fiber 3.

Known as another type of conventional system is an optical relay transmission system which uses optical direct amplifier repeaters 4A (which directly amplify an optical signal) instead of the repeaters shown in Fig.13.

Referring to Fig.14, the structure of the optical direct amplifier repeater 4A is explained below.

The optical direct amplifier repeater 4A is composed of an erbium doped fiber (EDFA) 13 which amplifies incoming optical signal PSin through a multiplexer 11, and a feedback circuit which maintains the amplitude of the amplified signal PSout to be outputted through a demultiplexer 14 constant.

Next is an explanation of optical signal PSin which is outputted from the terminal station 1 or 2. As shown in Fig.15 (spectral chart), optical signal PSin consists of a main signal f_0 (carrier wave); main signal control pilot signal P which is generated by superimposing pilot signal f_p on main signal f_0 by amplitude modulation; supervisory response signal SVRES which is generated by superimposing response signal f_{res} on main signal f_0 by amplitude modulation; and supervisory signal SV which is generated by superimposing supervisory signal f_{sv} on main signal f_0 by amplitude modulation.

Again, referring to Fig.14, the optical direct amplifier repeater 4A is explained below. The multiplexer 11 combines two different types of light with different wavelengths and outputs the combined light as a single optical signal. In this example, optical signal PSin which comes from the terminal station 1 and enters through the

optical fiber 3 is combined with pumping light from an optical coupler 12 and the combined light is outputted.

The optical signal outputted from the multiplexer 11 is amplified by EDFA 13. The EDFA 13 is an optical fiber doped with erbium (Er) as a rare-earth element. For example, as signal light enters an Er atom in the high energy optical fiber pumped by pumping light with $1.48\ \mu\text{m}$ wavelength, induced emission occurs and the power of the signal light gradually increases along the optical fiber. In short, the optical signal is amplified.

The demultiplexer 14 divides one optical signal into two optical signals. The optical signal amplified by EDFA 13 is divided and sent to the optical fiber 3 and an O/E conversion circuit 15. The O/E conversion circuit 15 converts an optical signal from the demultiplexer 14 into an electric signal and uses a photodiode as a light receiving device for receiving signal light. The electric current which flows as the photodiode receives signal light is amplified by an amplifying means like a transistor and outputted as electric signal EPS_{in} .

In Fig.14, 16 represents a first band pass filter (first BPF), 17 a second band pass filter (second BPF), and 18 a third band pass filter (third BPF). The first BPF 16 demodulates the electric signal EPS_{in} from the O/E conversion circuit 15 to take an electric signal E_{fp} corresponding to a pilot signal f_{p} ; the second BPF 17 demodulates the electric signal EPS_{in} to take an electric signal E_{fres} corresponding to a response signal f_{res} ; and the third BPF 18 demodulates the electric signal EPS_{in} to take an electric signal E_{fsv} corresponding to a supervisory signal f_{sv} .

19 represents an APC (Automatic Power Control) circuit which controls the power of main signal f_0 by the signal E_{fp} taken by the first BPF 16 to set the gain of the optical direct amplifier repeater 4A to a desired level. 20 represents an APC (Automatic Power Control) circuit which controls the amplitude of the signal E_{fres} taken by the second BPF 17 in a way to maintain it constant. 21 represents a supervisory signal processing circuit which makes the signal E_{fsv} taken by the third BPF 18 a command to control operation as desired using the command (for example, turn on or off the AGC circuit 20).

22 represents an E/O conversion circuit which converts an electric signal into an optical signal. It is composed of a pumping LD (Laser Diode) 22a and an LD drive circuit 22b. In this E/O conversion circuit 22, the LD drive circuit 22b receives signals from the APC circuit 19, AGC circuit 20 and supervisory signal processing circuit 21 and drives the pumping LD 22a using these signals to let the pumping LD 22 output pumping light through the optical coupler 12 to the multiplexer 11. 23 represents an

E/O conversion circuit which is composed of a pumping LD 23a and an LD drive circuit 23b, like the E/O conversion circuit 22. It is used as an emergency circuit. In other words, the E/O conversion circuit 22 is usually used; if the E/O conversion circuit 22 malfunctions for some trouble, the E/O conversion circuit 23 is used. Switching between the E/O conversion circuits 22 and 23 is done by controlling the optical coupler 12 according to a command which the supervisory signal processing circuit 21 generates by digitalization of the supervisory signal f_{sv} sent from the terminal station 1.

Problem to be Solved by the Invention

In the above optical relay transmission system, the gain of the repeaters 4 or optical direct amplifier repeaters 4A (provided in the line between the terminal stations 1 and 2) changes and therefore if a gain decrease occurs, it is necessary to control the gain to set it to a desired level.

This control is performed, for example, by means of pilot signal f_p for gain control which the terminal station 1 issues. However, the pilot signal f_p which is issued from the terminal station 1 has a single frequency and the repeaters 4 or optical direct amplifier repeaters 4A are all structurally equal, and therefore the pilot signal changes the gains of all the repeaters 4 or optical direct amplifier repeaters 4A, whichever repeater 4 or optical direct amplifier repeater 4A should be gain-controlled. This means that the gain for the overall system increases more than necessary, leading to wasteful power consumption and a higher running cost.

Besides, since the gain is not equal among the repeaters 4 or optical direct amplifier repeaters 4A, a signal deterioration may occur and an adequate signal may not be transmitted.

The present invention has been made in view of the above circumstances and provides an optical relay transmission system which uses optical direct amplifier repeaters to control their gains individually and set the gain of each of the optical direct amplifier repeaters to a desired level and thereby eliminates wasteful power consumption, reduces the running cost and also prevents a signal deterioration to assure transmission of an adequate signal.

Means for Solving the Problem

Fig.1 illustrates the principle of the present invention.

As illustrated in Fig.1, in an optical relay transmission system, plural optical direct amplifier repeaters 10A to 10N for directly amplifying an optical signal are provided in an optical fiber 3 line connecting terminal stations 1, 2 and while the plural

optical direct amplifier repeaters 10A to 10N are gain-controlled by a pilot signal superimposed by amplitude modulation on a main signal as an optical signal which is sent from one terminal station 1 of both the terminal stations 1, 2 and transmitted through the optical fiber 3, the optical signal is transmitted through the optical fiber 3 to the other terminal station 2. The system is configured as follows. The terminal stations 1 and 2 respectively have pilot signal generating means 1a and 2a to generate plural pilot signals which are as many as the plural optical direct amplifier repeaters 10A to 10N and different in frequency from each other. In addition, the plural optical direct amplifier repeaters 10A to 10N respectively have band pass filters 16a to 16n which have different frequency pass bands each corresponding to either of the frequencies of the plural pilot signals. A desired optical direct amplifier repeater among the plural optical direct amplifier repeaters 10A is gain-controlled by a pilot signal passing through its band pass filter (16a).

In addition to the above components of the optical direct amplifier repeaters 10A to 10N, optical direct amplifier repeaters 30A to 30N each having a common band pass filter 31 with a frequency pass band corresponding to the frequency of a single pilot signal may be provided to gain-control the optical direct amplifier repeaters 30A to 30N on a common basis by sending a single pilot signal from the terminal station 1 or 2.

Function

According to the present invention, plural pilot signals with different frequencies which are generated by a pilot signal generating means in a terminal station are superimposed on a main optical signal by amplitude modulation and the resultant signal is transmitted through an optical fiber to optical direct amplifier repeaters. Pilot signals with frequencies corresponding to the frequency pass bands of the band pass filters of the optical direct amplifier repeaters are demodulated by the band pass filters and the demodulated pilot signals are used to gain-control the optical direct amplifier repeaters. In other words, by altering the modulation factor for a pilot signal with a frequency corresponding to the frequency pass band of an optical direct amplifier repeater to be gain-controlled, the power of pumping light is varied to gain-control the optical direct amplifier repeater individually.

In addition, when the above optical direct amplifier repeaters have each a common band pass filter for demodulating a single pilot signal with a frequency which is different from the frequency of the above pilot signal, it is also possible to gain-control each optical direct amplifier repeater on a common basis by superimposing the single pilot signal on the main optical signal and transmitting it.

Preferred Embodiments

Next, preferred embodiments of the present invention will be described referring to the accompanying drawings.

Fig.2 illustrates an optical relay transmission system according to a first embodiment of the present invention; Fig.3 shows the structure of an optical direct amplifier repeater shown in Fig.2; Fig.4 is a spectral chart for pilot signals included in an optical signal which is sent from a terminal station shown in Fig.2. In these figures, the same components as those of the conventional system shown in Figs. 13 to 15 are designated by the same reference numerals and their descriptions are omitted here.

The optical relay transmission system according to this first embodiment is different from the conventional optical relay transmission system based on optical direct amplifier repeaters as follows. Pilot signals (f_{p1} to f_{pn}) which are as many as plural optical direct amplifier repeaters 10A to 10N (see Fig.2) and different in frequency from each other are used as pilot signals which are sent from the terminal station 1 or 2, as shown in Fig.4 and these pilot signals f_{p1} to f_{pn} are respectively superimposed on main signal f_0 by amplitude modulation and resultant main signal control pilot signals P1 to Pn are sent to the optical fiber 3. In addition, as shown in Fig.3, optical direct amplifier repeaters 10A to 10N have band pass filters BPF 16a to BPF 16n which have different frequency pass bands each corresponding to either of the frequencies of pilot signals f_{p1} to f_{pn} .

In this constitution, for example, since in the optical direct amplifier repeater 10A, only electric signal E_{fp1} corresponding to pilot signal f_{p1} for optical signal PSin 1 sent from the terminal station 1 can be demodulated by its first BPF 16a, in order to control the gain of the optical direct amplifier repeater 10A the modulation factor for pilot signal f_{p1} is altered to change the power of pumping light emitted from the pumping LD 22a. Similarly, in order to control the gain of the optical direct amplifier repeater 10B, the modulation factor for pilot signal f_{p2} is altered; in order to control the gain of the optical direct amplifier repeater 10C, the modulation factor for pilot signal f_{p3} is altered; and in order to control the gain of the optical direct amplifier repeater 10N, the modulation factor for pilot signal f_{pn} is altered. Therefore, in this optical relay transmission system, the optical direct amplifier repeaters 10A to 10N can be individually gain-controlled.

Next, a second embodiment of the present invention will be described referring to Figs.5 to 7.

Fig.5 illustrates an optical relay transmission system according to the second

embodiment of the present invention; Fig.6 shows the structure of the optical direct amplifier repeater shown in Fig.5; and Fig.7 is a spectral chart for pilot signals included in an optical signal which is sent from a terminal station. In these figures, the same components as those of the first embodiment shown in Figs. 2 to 4 are designated by the same reference numerals and their descriptions are omitted here.

The second embodiment shown in these figures is different from the first embodiment as follows. A fourth band pass filter (fourth BPF) 31 is added to each of optical direct amplifier repeaters 30A to 30N located between the terminal stations 1 and 2 as shown in Fig.6. In addition, as shown in Fig.7, pilot signal f_{p0} which passes only through the fourth BPF 31 is superimposed on main signal f_0 of optical signal PSin 2 by amplitude modulation.

In this optical relay transmission system, the optical direct amplifier repeaters 30A to 30N can be individually gain-controlled, like the first embodiment, and also can be gain-controlled by pilot signal f_{p0} on a common basis.

Next, a third embodiment of the present invention will be described referring to Figs.8 and 9.

Fig.8 illustrates an optical relay transmission system according to the third embodiment of the present invention; and Fig.9 shows the structure of the optical direct amplifier repeater shown in Fig.8. In these figures, the same components as those of the second embodiment shown in Figs. 5 and 6 are designated by the same reference numerals and their descriptions are omitted here.

The third embodiment shown in these figures is different from the second embodiment in that plural optical direct amplifier repeaters 40 as shown in Fig.9 are inserted between optical direct amplifier repeaters 30A to 30N located between the terminal stations 1 and 2 in a way that one optical direct amplifier 40 lies between two optical direct amplifier repeaters (30A to 30N).

Each optical direct amplifier repeater 40 has the fourth BPF 31 (which demodulates only pilot signal f_{p0}) between the O/E conversion circuit 15 and the APC circuit 19, as shown in Fig.9.

In this optical relay transmission system, the optical direct amplifier repeaters 30A to 30N can be individually gain-controlled, like the second embodiment, and also the optical direct amplifier repeaters 30A to 30N and 40 can be gain-controlled by pilot signal f_{p0} on a common basis.

Although in the third embodiment, each of the plural optical direct amplifier repeaters 40 is inserted between two optical direct amplifier repeaters (30A to 30N), they need not be so inserted and the number of inserted optical direct amplifier

repeaters 40 is not fixed.

Next, a fourth embodiment of the present invention will be described referring to Fig.10.

Fig.10 illustrates an optical relay transmission system according to the fourth embodiment of the present invention. In this figure, the same components as those of the second embodiment shown in Fig. 5 are designated by the same reference numerals and their descriptions are omitted here.

The fourth embodiment shown in this figure is different from the second embodiment in that optical direct amplifier repeater blocks 30A' to 30N', each block consisting of plural optical direct amplifier repeater 30A to 30N, are successively provided between the terminal stations 1 and 2 as shown in Fig.10 and the optical direct amplifier repeaters 30A to 30N can be gain-controlled block by block. Like the second embodiment, the optical direct amplifier repeaters 30A to 30N can be gain-controlled on a common basis.

According to the first to fourth embodiments, the optical direct amplifier repeaters 10A to 10N, 30A to 30N and 40 are gain-controlled by pilot signals f_{p1} to f_{pn} or pilot signals f_{p0} to f_{pn} ; however, the APC circuit 19 may be controlled using A DC signal outputted from the supervisory signal processing circuit 21 in order to control the gains of the optical direct amplifier repeaters.

Thus, the optical direct amplifier repeaters are gain-controlled as follows. A signal for controlling the gain of the APC circuit 19 is superimposed on supervisory signal f_{sv} for optical signal PS_{in} sent from the terminal station 1 and the resultant signal is demodulated by the third BPF 18, then converted into a DC signal through a D/A conversion circuit 21a in the supervisory signal processing circuit 21 and the DC signal enters a gain control circuit 19a in the APC circuit 19. In other words, the gain control circuit 19a in the APC circuit 19 receives a DC signal as a result of conversion of the signal for controlling the gain of the APC circuit 19 and thus the APC circuit 19 itself is gain-controlled by the DC signal, thereby gain-controlling the optical direct amplifier repeaters.

In monitoring the gains of the optical direct amplifier repeaters in the first to fourth embodiments, it is possible to know the gains of the optical direct amplifier repeaters which are gain-controlled by pilot signals f_{p1} to f_{pn} or the gain of each block of successively connected optical direct amplifier repeaters, by checking the modulation factor for each of pilot signals f_{p1} to f_{pn} . For example, in the first embodiment shown in Fig.1, the modulation factor for each of pilot signals f_{p1} to f_{pn} is displayed on a monitor 50 as shown in Fig.12 so that an operator can know the gains of optical direct amplifier

repeaters 10A to 10N corresponding to pilot signals f_{p1} to f_{pn} . In other words, if the operator wishes to know the gain of the optical direct amplifier repeater 10A, he/she can know it by checking the modulation factor for pilot signal f_{p1} displayed on the monitor 50.

Effects of the Invention

As discussed so far, according to the present invention, plural optical direct amplifier repeaters which are provided in an optical fiber line between two terminal stations can be individually gain-controlled so that all optical direct amplifier repeaters can be set to desired gain levels; as a consequence, wasteful power consumption is prevented and the running cost is reduced.

Furthermore, the gains of all optical direct amplifier repeaters can be made equal so that a signal deterioration is prevented and an adequate signal is transmitted.

Besides, since the modulation factor for a pilot signal for controlling the gain of each optical direct amplifier repeater can be displayed on a monitor, the gain of an optical direct amplifier repeater can be known from the modulation factor of the optical direct amplifier repeater displayed on the monitor.

4. Brief Description of the Drawings

Fig.1 illustrates the principle of the present invention;

Fig.2 illustrates an optical relay transmission system according to the first embodiment of the present invention;

Fig.3 shows the structure of the optical direct amplifier repeater shown in Fig.2;

Fig.4 is a spectral chart for pilot signals for an optical signal sent from a terminal station shown in Fig.2;

Fig.5 illustrates an optical relay transmission system according to the second embodiment of the present invention;

Fig.6 shows the structure of the optical direct amplifier repeater shown in Fig.5;

Fig.7 is a spectral chart for pilot signals for an optical signal sent from a terminal station shown in Fig.5;

Fig.8 illustrates an optical relay transmission system according to the third embodiment of the present invention;

Fig.9 shows the structure of one of the two types of optical direct amplifier repeaters shown in Fig.8;

Fig.10 illustrates an optical relay transmission system according to the third embodiment of the present invention;

Fig.11 shows the structure of another type of optical direct amplifier repeater according to the present invention;

Fig.12 illustrates a method of monitoring the gains of optical direct amplifier repeaters according to the present invention;

Fig.13 illustrates the conventional optical relay transmission system;

Fig.14 shows the structure of the conventional optical relay transmission system; and

Fig.15 is a spectral chart for pilot signals for an optical signal sent from a terminal station shown in Fig.13.

1, 2 ... Terminal station

1a, 2a ... Pilot signal generating means

3 ... Optical fiber

16a-16n, 31 ... Band pass filter

10A-10N, 30A-30N, 40 ... Optical direct amplifier repeater

19 ... Gain control means

21a ... D/A conversion means

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Fig.1

	本発明の原理図	Principle of the Invention
1,2	端局	Terminal Station
1a, 2a	パイロット信号発生手段	Pilot signal generating means
3	光ファイバ	Optical fiber
10A-10N	光直接増幅中継器	Optical direct amplifier repeater
16A-16N	バンドパスフィルタ	Band pass filter

Fig.2

	第1実施例による光中継伝送方式の図	Optical relay transmission system (first embodiment)
1,2	端局	Terminal station

Fig.3

	第2図に示す光直接増幅中継器の構成図	Structure of the optical direct amplifier repeater shown in Fig.2
11	合波器	Multiplexer
12	光カプラ	Optical coupler
14	分岐器	Demultiplexer
15	O/E 変換回路	O/E conversion circuit
16a-16n	第1BPF	First BPF
17	第2BPF	Second BPF
18	第3BPF	Third BPF
19	APC 回路	APC circuit
20	AGC 回路	AGC circuit
21	監視系信号処理演算回路	Supervisory signal processing circuit
22a	ポンピング用 LD (N)	Pumping LD (N)
22b	LD 駆動回路	LD drive circuit
23a	ポンピング用 LD (E)	Pumping LD (E)
23b	LD 駆動回路	LD drive circuit

Fig.4

スペクトル図	Spectral chart
主信号	Main signal

Fig.5

第2実施例による光中継伝送方式の図	Optical relay transmission system (second embodiment)
1,2 端局	Terminal station

Fig.6

	第5図に示す光直接増幅中継器の構成図	Structure of the optical direct amplifier repeater shown in Fig.5
11	合波器	Multiplexer
12	光カプラ	Optical coupler
14	分岐器	Demultiplexer
15	O/E 変換回路	O/E conversion circuit
16a-16n	第1BPF	First BPF
17	第2BPF	Second BPF
18	第3BPF	Third BPF
19	APC 回路	APC circuit
20	AGC 回路	AGC circuit
21	監視系信号処理演算回路	Supervisory signal processing circuit
22a	ポンピング用 LD (N)	Pumping LD (N)
22b	LD 駆動回路	LD drive circuit
23a	ポンピング用 LD (E)	Pumping LD (E)
23b	LD 駆動回路	LD drive circuit

Fig.7

スペクトル図	Spectral chart
主信号	Main signal

Fig.8

第3実施例による光中継伝送方式の図	Optical relay transmission system (third embodiment)
1,2 端局	Terminal station

Fig.9

	第8図に示す光直接増幅中継器の構成図	Structure of the optical direct amplifier repeater shown in Fig.8
11	合波器	Multiplexer
12	光カプラ	Optical coupler
14	分岐器	Demultiplexer
15	O/E 変換回路	O/E conversion circuit
31	第4BPF	Fourth BPF
17	第2BPF	Second BPF
18	第3BPF	Third BPF
19	APC 回路	APC circuit
20	AGC 回路	AGC circuit
21	監視系信号処理演算回路	Supervisory signal processing circuit
22a	ポンピング用 LD (N)	Pumping LD (N)
22b	LD 駆動回路	LD drive circuit
23a	ポンピング用 LD (E)	Pumping LD (E)
23b	LD 駆動回路	LD drive circuit

Fig.10

第3実施例による光中継伝送方式の図	Optical relay transmission system (third embodiment)
1,2 端局	Terminal station

Fig.11

	光直接増幅中継器の構成図	Structure of an optical direct amplifier repeater
11	合波器	Multiplexer
12	光カプラ	Optical coupler
14	分岐器	Demultiplexer
15	O/E 変換回路	O/E conversion circuit
16a-16n	第 1BPF	First BPF
17	第 2BPF	Second BPF
18	第 3BPF	Third BPF
20	AGC 回路	AGC circuit
22a	ポンピング用 LD (N)	Pumping LD (N)
22b	LD 駆動回路	LD drive circuit
23a	ポンピング用 LD (E)	Pumping LD (E)
23b	LD 駆動回路	LD drive circuit

Fig.12

ゲインのモニタリング方法を説明する為の図	Gain monitoring method
50 モニタ	Monitor
LD 駆動回路	LD drive circuit
ポンピング用 LD	Pumping LD

Fig.13

従来の光中継伝送方式の図	Conventional optical relay transmission system
1,2 端局	Terminal station

Fig.14

	従来の光中継伝送方式の図	Conventional optical relay transmission system
11	合波器	Multiplexer
12	光カプラ	Optical coupler
14	分岐器	Demultiplexer
15	O/E 変換回路	O/E conversion circuit
16a-16n	第 1BPF	First BPF
17	第 2BPF	Second BPF
18	第 3BPF	Third BPF
19	APC 回路	APC circuit
20	AGC 回路	AGC circuit
21	監視系信号処理演算回路	Supervisory signal processing circuit
22a	ポンピング用 LD (N)	Pumping LD (N)
22b	LD 駆動回路	LD drive circuit
23a	ポンピング用 LD (E)	Pumping LD (E)
23b	LD 駆動回路	LD drive circuit

Fig.15

スペクトル図	Spectral chart
主信号	Main signal